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Germplasm evaluation of aonla (*Emblica officinalis* Gaertn.) against rust (*Ravenelia emblicae* Styd.) for resistance

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Abstract
Aonla, also known as Indian gooseberry or *Emblica officinalis* Gaertn., holds great significance as an indigenous fruit in India. It belongs to the family Euphorbiaceae and the order Euphorbiales. The present investigation was conducted during rabi season 2022 crop seasons at Main Experimental Station, A.N.D.U.A.&T., Kumarganj, Ayodhya to tested the resistance of Fifteen commercial cvs. /Germplasm against *Ravenelia emblicae* Styd. under natural conditions. Each germplasm was screened, first appearance of the disease in September month, out of 15 germplasm, results was found seven germplasm were moderately susceptible (BSR-1, Anand-1, NA-25, NA-26 NA-27, NA-29, NA-32), seven were susceptible (NA-4, NA-5, NA-6, NA-7, NA-10, NA-20, Francis) and one was highly susceptible (Chakaiya) to aonla rust. among the 15 germplasms, NA-29 showed the least severity of aonla rust (15.66%), However, highest percent disease severity (PDS) was observed in Chakaiya (55.33%). The highest rate of infection, which was occurred in NA-4 (0.140) and Chakaiya (0.124). however, the minimum rate of infection was observed in both Anand-1 and BSR-1 which was 0.010 and 0.024, respectively. AUDPC calculated for the 15 germplasms on the basis of the disease severity varied from 624.9 to 3909.55 showing the fast progress of the disease in all germplasm.

Keywords: *Emblica officinalis* Gaertn., aonla rust, *Ravenelia emblicae* Styd., screening, AUDPC, Infection rate

Introduction

Aonla or Indian gooseberry (*Emblica officinalis* Gaertn.) is an important indigenous fruit of India which belongs to the family Euphorbiaceae and the order Euphorbiales (Newman *et al.,* 2000) [10] and also known as amla, amlaki, amali and ambala in different parts of India. It is a native of Southern Eastern Asia, particularly Central and South India (Bose and Mitra, 1990) [4]. India ranks first in the world in area and production of aonla crop, occupies an area of 103.55 thousand ha with a production of 1221.25 thousand metric tonnes (Wali *et al.,* 2015) [15]. According to the National Horticulture Board (2020-21) data, aonla cultivation covers approximately 100 thousand hectares of land, yielding an annual production of around 1197 thousand metric tonnes. Uttar Pradesh is renowned for producing high-quality aonla fruit and occupies an area of 36.70 thousand hectares with a production of 402.63 thousand metric tonnes (2020-21). Naturally growing aonla trees are also found in Sri Lanka, Cuba, Puerto Rico, US (Hawaii and Florida), Iran, Iraq, Pakistan, China, Malaysia, Bhutan, Thailand, Vietnam, Philippines, Trinidad, Panama and Japan (Benthal, 1946) [3]. The information on different aonla species and their status of prevalence in different parts of the world, particularly in South and South East Asia (Pathak *et al.,* 2003) [12]. Aonla is commercially cultivated in Uttar Pradesh comparing Pratapgarh, Raebareli, Varanasi, Jaunpur, Sultanpur, Azamgarh and Faizabad district. Aonla being a hardy in nature, is successfully cultivated in wide range of variable soil (Sodic and saline soil) and climatic condition *viz*, arid and semi-arid to dry hot and cold arid regions, rainfed to rainfall area. The fruit is highly nutritive and well known for its antioxidant properties. It is second richest source of vitamin 'C' next to Barbados cherry (Asenjo, 1953) [2] and also rich in phenolic substances. It is having medicinal as well as therapeutic vales. The fruit are used to make preserves, Candy, dried chips, jellies, pickles, powder, etc. and possess diverse medicinal and industrial uses. The famous Aurvedic medicines chyavanprash and Trifla are prepared from aonla fruits which are commonly consumed for growth. Vigour and general uptake of human health. It contains 500 to 1500 mg ascorbic acid/100 g fruit pulp. It is also a fair source of carotene, thiamine, riboflavin, carbohydrates and minerals like iron, phosphorus, calcium and magnesium.

Hence, Aonla rust, caused by *Ravenalia emblicae* var. *fructicolae* Syd., poses a serious challenge in aonla cultivation areas across the country, particularly in Uttar Pradesh. With the expansion of aonla orchards in arid regions, it is crucial to investigate the prevalence of aonla rust, the influence of weather conditions on its development, identify resistant cultivars.

Materials and Methods
Experiment was conducted at Main Experimental Station (MES), Department of Horticulture, A.N.D.U.A.&T., Kumarganj, Ayodhya (located at 26^0 47''N, 81^0 28''E) by planting fifteen commercial cultivar / germplasm *viz.* Chakaiya, NA-10, NA-20, Anand-1, BSR-1, Francis, NA-6, NA-7, NA-5, NA-4, NA-25, NA-26, NA-27, NA-29 and NA-32 in three replications in randomized Block Design having spacing 8 x 8 m plant to plant. To test the resistance against rust disease of aonla caused by *Ravenalia emblicae* Styd. under natural conditions. Observation regarding PDI recorded on 50 randomly selected fruits per replication and 150 fruits per treatment when disease severity was at peak using 0-4 scale for screening and the screening of each germplasm/cultivar was divided into the fourth part of the plant, and the severity of aonla rust disease was observed. A total of 100 leaves were observed, with 25 leaves taken from each part of the plant, and it was observed how many leaves were infected. All recommended agronomical and cultural practices were followed for raising a good crop.

Under field conditions plant observed for first appearance of disease and disease intensity of each germplasm. Final observation on the affected plant were recorded by randomly selected 50 fruits at the time of harvesting and graded as per 0-4 scale (table 1) of McKinney (1923) [8].

Table 1: McKinney Scale (0-4 grade)

Scale	Percent fruit/ leaves infection	Reaction
0	0	Immune
1	1-5	Resistant
2	6-20	Moderately Susceptible
3	21-50	Susceptible
4	51-100	Highly Susceptible

The percent disease intensity (PDI) was calculated by employing formulas mentioned below:

$$\text{Percent disease severity} = \frac{\text{Sum of all numerical ratings}}{\text{Total no. of leaves examined x Highest rating}} \times 100$$

Apparent infection Rate of aonla rust
The apparent infection rate of disease development (r/unit/day), the rate of infection of aonla rust observed that first appearance of the disease in each germplasm after 10, 30, 60, 90, 120 days during the year 2022. The rate of infection was calculated by using the following formula given by van der Plank (1963) [14].

$$r = 2.3 / (t_2 - t_1) \log 10\ X_2/X_1$$

Where,
r = rate of infection
$t_2 - t_1$ = time interval
X_2 = disease at time t_2
X_1 = disease at time t_1

Area under disease progress curve (AUDPC)
The most commonly used method for estimating the AUDPC, the trapezoidal method, is to check the time variable (hours, days, weeks, months or years) and calculate the average disease intensity between each pair of adjacent time points. It is given by following formulas suggested by Madden *et al.,* (2007) [7].

$$AUDPC = \sum_{i=1}^{n-1} \frac{y_i + y_{i+1}}{2} X(t_{i+1} - t_i)$$

Where,
y_i =an assessment of a disease at the ith observation
t_i = time (in days, hours, etc.) at the ith observation
n = the total number of observations.

Results and Discussion
The use of resistant cultivars is beneficial in preventing plant diseases, including aonla rust. To assess the disease reactions against aonla rust caused by *Ravenalia emblicae* var. *fructicolae* Syd.

Fifteen commercial cvs. /Germplasm of aonla were screened during rabi season in the year 2022. The data presented in table 2 and figure 1, observed that the percent disease severity of aonla rust at first appearance of the disease in each germplasm after 10, 30, 60, 90, 120 days during the year 2022. Among the 15 germplasms, NA-29 showed the least severity of rust at (15.66%), followed by NA-25 (16%), NA-27 (18.33%), NA-26 (19.66%), BSR-1 (20.00%), and NA-32 (20.00%). However, the highest percent disease severity (PDS) was observed in Chakaiya (55.33%). Similar results were observed that Rawal (1993) [13], Nirwan *et al.,* (1969) [11], Anonymous (1997) [1], Jat (1999) [6], Devi *et al.* (2022) [5].

Out of the 15 germplasms table 3, seven germplasms were moderately susceptible (BSR-1, Anand-1, NA-27, NA-29, NA-32, NA-25, NA-26), seven were susceptible (NA-20, NA-10, NA-5, NA-6, NA-7, Francis, NA-4), and one was highly susceptible (Chakaiya) to aonla rust. Similarly result was found by Anonymous (1997) [1] during last week of December ten aonla cultivars/ genotypes were screened against rust disease of aonla. Cultivar NA-7, NA-4 and Chakaiya showed susceptible reaction whereas Banarasi, Francis, Krishna, NA-6, NA-8 and NA-9 had moderately susceptible reaction. Similarly, the data was purposed by Jat (1999) [6] reported that commercially cultivated cultivars of aonla was susceptible except cultivars NA-4, NA-6 and NA-10 showed moderately susceptible. According to Devi *et al.* (2022) [5] observed eight cultivars of aonla screened against rust, among these NA-7 and Gomo Kirti were found resistant, NA-6, NA-10 and Francis were moderately resistant, Chakaiya were found to be moderately resistant moderately susceptible whereas, Banarasi and Desi aonla were susceptible. Similar findings have been advocated by Nirwan *et al.,* (1969) [11] who reported that Desi aonla cultivar was severely affected with aonla rust, while Chakaiya and Banarasi were relatively free from aonla rust.

Apparent infection rate of aonla rust
The data proposed in the table 2 and figure 2. The highest rate of infection, which was 0.140, occurred in NA-4 and Chakaiya (0.124) The rate of infection was slightly lower at

0.122 in the germplasm NA-20. However, the minimum rate of infection was observed in both cultivars Anand-1 and BSR-1 which was 0.010 and 0.024 respectively. Similarly, results were observed infection rate of aonla rust Devi *et al.,* (2022) [5]. Maximum rate of infection *viz.* 0.12 was observed, it was followed by 0.08, However, minimum rate of infection *viz.* -0.01.

Area under disease progress curve (AUDPC)

It is evident from the result proposed in table 2 and figure 2, the AUDPC calculated for the 15 germplasms on the basis of the disease severity varied from 624.9 (NA-29) to 3909.55 (Chakaiya) showing the fast progress of the disease in all germplasm. It was observed that different aonla germplasm expressed varied types of disease response against *Ravenalia emblicae* under natural conditions.

Table 2: Screening of aonla rust on in different germplasm /cultivars and its reactions with respect to apparent infection rate and AUDPC during the year 2022

| Cultivars/ germplasm	Date of 1st appearance	Percent disease severity at 120 days after appearance	Reactions	Infection rate	AUDPC
NA-20	03 September	46.33	S	0.122	2941.15
NA-10	12 September	40.66	S	0.037	2673.8
Chakaiya	02 September	55.33	HS	0.124	3909.55
NA-5	20 September	29.28	S	0.051	1504.4
NA-6	12 September	38.66	S	0.049	2304.6
NA-7	02 September	43.33	S	0.121	2680.5
Francis	25 September	31.66	S	0.064	1751.2
BSR-1	07 October	20.00	MS	0.024	1049.7
NA-4	06 September	45.66	S	0.140	2803.15
Anand-1	12 October	23.00	MS	0.010	1108.2
NA-25	06 October	16.00	MS	0.037	676.8
NA-26	20 September	19.66	MS	0.071	1042.85
NA-27	07 October	18.33	MS	0.031	982.35
NA-29	10 October	15.66	MS	0.040	624.9
NA-32	21 September	20.00	MS	0.055	1090.75
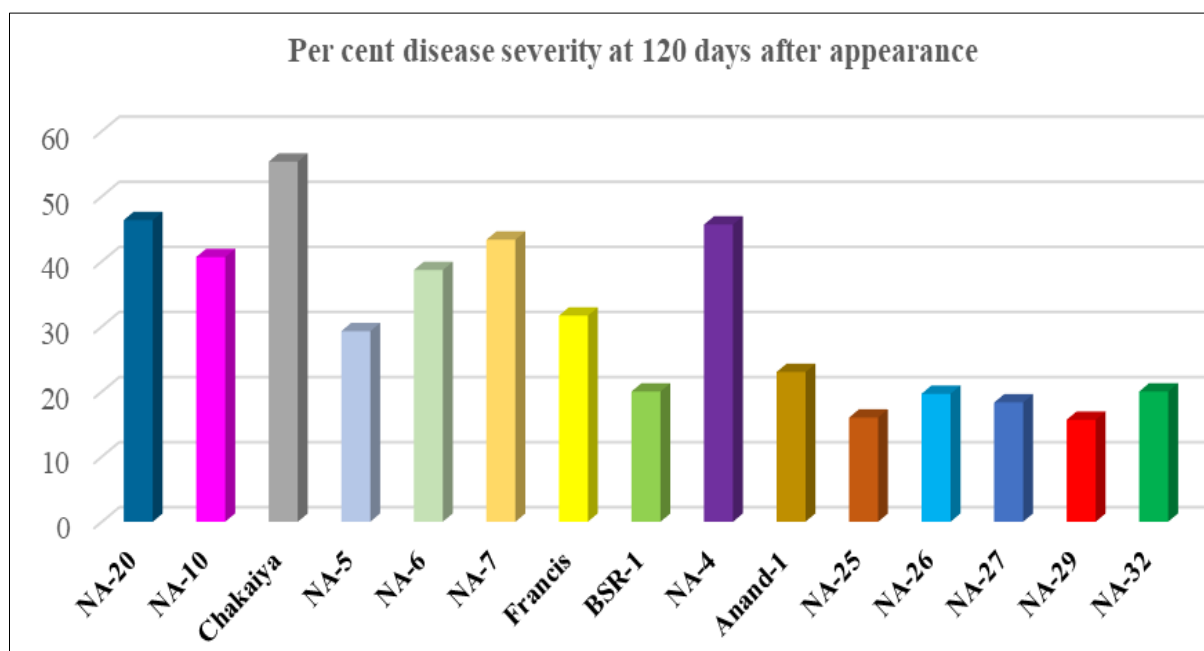
Fig 1: Evaluation of aonla rust on different germplasm with percent disease severity

Table 3: Reaction of germplasm/cultivars of aonla against rust disease during the year 2022

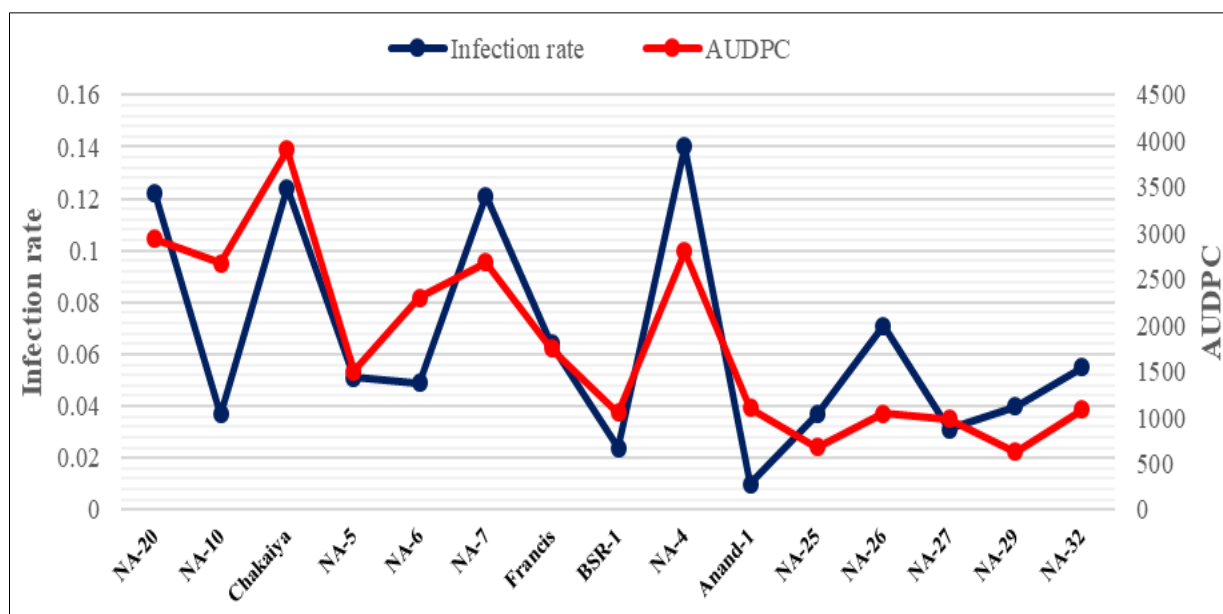| Reaction	Number of Genotypes	Name of Genotypes
Immune	-	Nil
Resistant (R) (0.1 to 5%)	-	Nil
Moderately Susceptible (MS) (5.1 to 20%)	7	BSR-1, Anand-1, NA-25, NA-26, NA-27, NA-29, NA-32
Susceptible (S) (20.1 to 50%)	7	NA-20, NA-10, NA-5, NA-6, NA-7, Francis, NA-4
Highly Susceptible (HS) (>50.0%)	1	Chakaiya

Fig 2: Apparent infection rate and AUDPC of the aonla rust on different germplasm

Conclusion
Resistant cultivars like NA-29 showed the least severity (15.66%) of aonla rust, while Chakaiya exhibited the highest severity (55.33%). Additionally, the highest and lowest rate of infection, which was 0.140 and 0.010, and AUDPC also varied from 624.9 to 3909.55 showing the fast progress of the disease among the different aonla germplasms. These findings emphasize the importance of utilizing resistant cultivars to prevent and manage aonla rust effectively.

Acknowledgements

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